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The Review And Adoption Of Recycled Plastic Micro Fibre (LDPE) As An Alternative Reinforcement Material In Green Concrete

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Abstract:
Plastic materials are widely used for various commercial and industrial applications due to its availability and affordability. The disposal of plastic wastes after utilization possesses a serious challenge to the environment. This incessant disposal of plastic waste materials motivates innovators to adopt these wastes as alternative and sustainable reinforcement material in green concrete. However, this manuscript reviews the use and adoption of plastic micro fibres as a reinforcement material in green concrete, highlighting its potential benefits, challenges, and future prospects. The plastic fibres incorporation into green concrete has gained attention due to its potential ability to improve the mechanical properties, such as: reduce shrinkage, tensile strength, and enhance durability. This article examines existing literature on the environmental impact assessment, durability, and mechanical properties of plastic fibre reinforced concrete (PFRC). Major findings show that PFRC exhibits enhanced toughness, crack resistance, and improved post-crack behaviour compared to traditional concrete. However, challenges, such as low dispersion, poor bonding, and optimal dosage of plastic fibre material exist in the green concrete. Recommendations for future research and practical applications are discussed.

Key Word: *Low-density polyethylene (LDPE); green concrete; recycled plastic fibers; sustainable construction; mechanical properties; durability; life cycle assessment; circular economy.*

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I. Introduction

The solid waste generation in the world has been increased due to rapid urbanization, expansion of infrastructure and changing consumption patterns and plastic waste (PW) is one of the most important pollution issues in the environment. The annual production of plastic is more than 400 million metric tonnes of which low density polyethylene (LDPE) takes about 15-20% of the production demand globally, mainly for flexible packaging, shopping bags, agricultural films and consumer goods [3, 4]. Even though a great effort has been made to collect and recycle LDPE, less than 10% of the post-consumer LDPE is actually recycled, with the rest going to landfills, incineration or natural ecosystems [5] [6]. At the same time, the construction industry accounts for almost 8% of global CO_2 emissions, mostly because of the manufacturing of ordinary Portland cement (OPC) and the extraction of virgin aggregates [7].

With the dual pressures of plastic pollution and construction-related resource depletion, research into sustainable and circular integration of materials has increased, making recycled plastic fibers a viable alternative to other reinforcement materials in green concrete [8] and [9].

Although there is a considerable body of literature on recycled polyethylene terephthalate (PET) fibers and polypropylene (PP) fibers in cementitious composites, there is less work that has been carried out on recycled LDPE fibers in systematic evaluations [10, 11]. This is an important research gap because the low density (range of ~0.91-0.94 g/cm^3), high ductility, chemical resistance and thermal stability of LDPE all contribute to its interaction with cement matrices [12]. RLDFs have been found to be beneficial for enhancing crack resistance, reducing plastic shrinkage, and increasing post-crack toughness, although there are some compromises in workability and compression strength at higher dosages [13] and [14]. In addition, the hydrophobic property of LDPE and the smooth surface morphology of the LDPE often give poor fiber-matrix bonding, and therefore, they need to be treated with surface treatments or modified mechanically to achieve the best reinforcement efficiency [15].

This review aims to systematically analyze the existing knowledge on the use of LDPE as an alternative reinforcement material in green concrete. The goals of the paper are:
(i) describe physical, mechanical properties and recycling pathways of LDPE;
(ii) discuss the application of RLDF in fresh, hardened and durability properties;

(iii) evaluate the environmental and economic sustainability from the LCA and circular economy approaches;
(iv) discuss the microstructural interactions and thermal behavior; and
(v) discuss the practical applications, standardization challenges and future research directions.

This review attempts to link empirical observations with sustainable construction principles to direct the research community, material engineers and policymakers towards scaling up the use of LDPE in sustainable concrete systems.

Table 1. Chemical composition of OPC

Oxide / Compound	*Percentage (%)*
Calcium oxide	62.68%
Silica	20.36%
Alumina	6.87%
Iron oxide	3.67%
Magnesia	1.77%
Sulphuric anhydride	2.24%
Tricalcium silicate	42.57%
Dicalcium silicate	26.33%
Tricalcium aluminate	12%
Tetra calcium alumino-ferrite	2.24%

Table 2. Physical Properties of Cement

Property	*Value*
Specific gravity of cement	3.13
Consistency	35%
Initial setting time	28 min

Table 3: Ten leading countries in which plastic waste is inadequately managed. [78]

S/N	*Country*	*Share of plastic inadequately managed (in percentage)*	*Per capita plastic waste (kg/person/day)*
1	North Korea	88%	0.054
2	Bangladesh	87%	0.034
3	Cambodia	87%	0.066
4	Myanmar	87%	0.075
5	Pakistan	86%	0.103
6	Papua New Guinea	86%	0.103
7	Solomon Islands	86%	0.103
8	Vietnam	86%	0.103
9	Democratic Republic of Congo	85%	0.045
10	India	85%	0.01

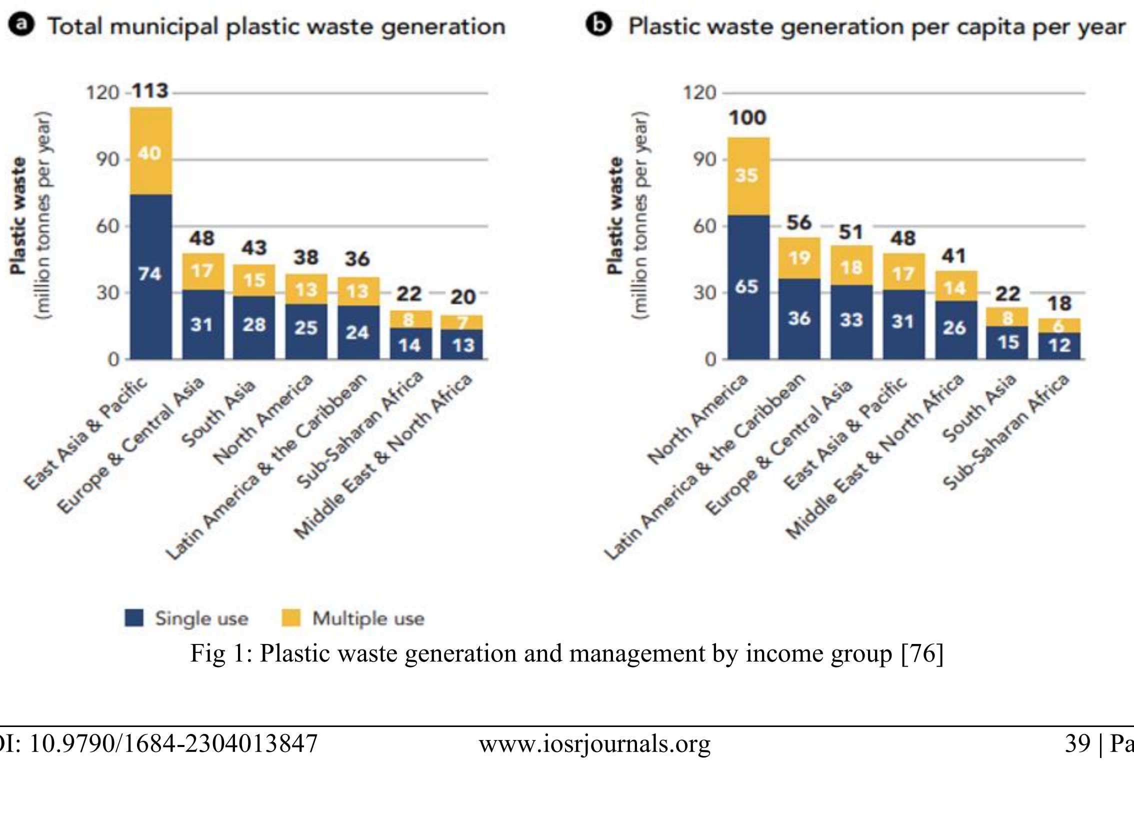

Fig 1: Plastic waste generation and management by income group [76]

As depicted in fig 1, the global situation of plastic pollution is shaped by a pivotal duality between urban scale and consumer lifestyle, which is particularly striking in the region. When considering amount, fig 1(a) shows that the highest number of tonnes of total municipal plastic waste is produced by rapidly urbanizing regions and growing infrastructure hubs, in particular the East Asia & Pacific region, at 113 million tonnes per year. On an individual basis, however, the evaluation of individual lives and changes in consumption patterns, as illustrated in fig 1(b), shows that North America generates a very large plastic waste per person per year of 100 units. Importantly, in both the overall regional waste stream and each measure, single-use plastics (dark blue) consistently make up more than 60% of the total material in each of the regions that have been surveyed.

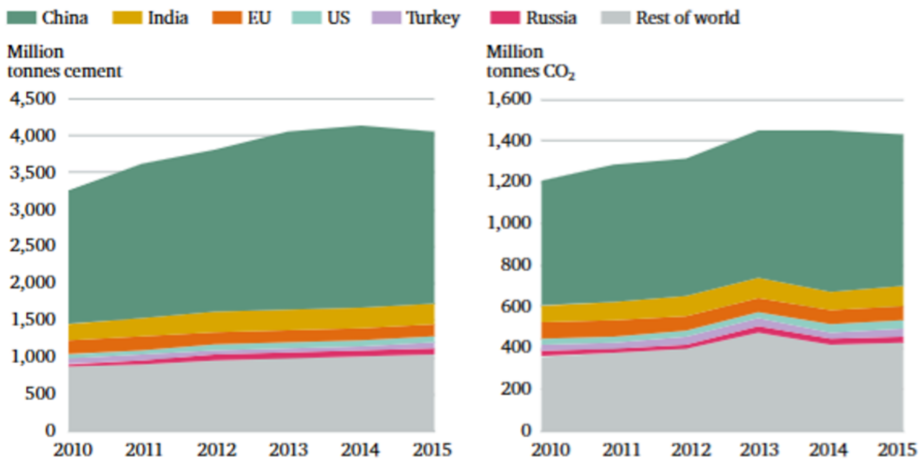

Fig 2: Cement production and Emissions 2010-2015 [76]

Cement is one of the essential feedstocks in the production of the world's most popular construction material: concrete. Every year, more than 4 billion tonnes of cement are produced. The chemical and thermal combustion processes involved in the production of cement are a major source of CO2 emissions, contributing around 8 per cent of annual global CO2 emissions.

II. LDPE Characteristics And Recycling Pathways

Physicochemical Properties of LDPE

LDPE is a thermoplastic polymer with a highly branched molecular structure, and has been characterized as being flexible, impact resistant and less crystalline than high-density polyethylene (HDPE), [16]. A general comparison of the important properties of LDPE with other commodity plastics commonly studied in concrete applications is given in Table 1.

Table 3: Physical Properties of LDPE

Property	***Value***
Tensile Strength	0.20 - 0.40 N/mm²
Notched Impact Strength	No break
Thermal Coefficient of Expansion	100 - 220 x 10^{-6}
Max. Continued Use Temperature	65 °C (149 °F)
Melting Point	110 °C (230 °F)
Glass Transition Temperature	-125 °C (-193 °F)
Density	0.910 - 0.940 kg/m³

The low tensile strength and low modulus of elasticity make LDPE unsuitable to use alone in structural applications, but if it is processed into fibers with the optimum aspect ratio, it is possible to use it to span microcracks and distribute stresses generated by tensile forces in the cementitious matrix [18]. It has excellent resistance to alkaline pore solution; however, it is also chemically inert which can reduce interfacial bonding properties unless modified [19].

Recycling and Fiber Production Techniques

The main recycling processes for LDPE consist of mechanical recycling, which consists of shredding, washing, sorting, and extrusion into pellets or fibers [20]. Primary recycling transforms LDPE into the same grade, and secondary recycling uses the material to create construction products, geomembranes or composite reinforcement of lower quality [21].

The less economically viable process of Tertiary (chemical) recycling – such as pyrolysis or depolymerization – is not suitable for LDPE because of its stable carbon-carbon backbone and branching structure [22].

In concrete applications, post-consumer LDPE is usually processed into short fibres through the following:

- Chopping/Cutting: Mechanical separation of films or bags into discrete fibers, 10 – 40 mm long, 0.1 – 0.5 mm thick.
- Extrusion and Drawing: LDPE is melted and extruded through a die and then drawn at a low temperature to increase the tensile strength and aspect ratio.
- Surface Treatment: Corona discharge, plasma treatment, chemical etching, or silane coupling to improve the hydrophilicity and cement adhesion [23, 24].

Research has shown that there is a strong relationship between the fiber geometry and the performance of concrete. Fiber aspect ratios ranging from 50 to 100 are considered optimal for crack bridging and fibers of longer length (more than 40 mm) may cause balling and adversely affect workability [25]. Fiber agglomeration must be avoided by appropriate dispersion measures such as pre-mixing with fine aggregates or using superplasticizers [26].

III. Economic And Sustainability Framework

Linear vs. Circular Economy Models

The traditional plastic waste management is following the linear economic model (LEM), that is, extraction, manufacturing, use for a short time and disposal. The economic loss associated with this model is significant and is estimated to be $80–120 billion per year, just from plastic packaging waste [28]. The circular economy model (CEM), however, focuses on resource retention, waste valorization and closed loop material flows [29]. The use of LDPE in concrete is in line with CEM principles as it allows the use of end-of-life packaging as a long-lasting construction material, increases material life cycle and decreases virgin resources extraction.

Fig 3: Flow chart of LEM

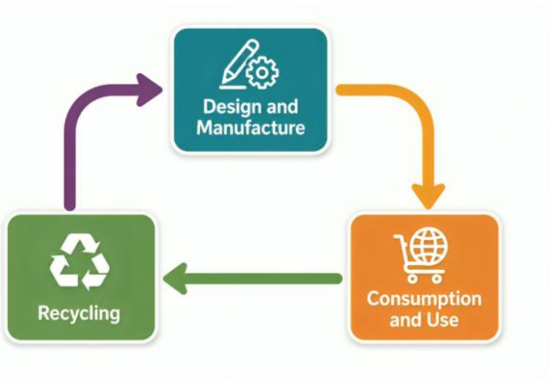

Fig 4: Flow chart of CEM

Life Cycle Assessment (LCA) Insights

The LCA methodologies, according to ISO 14044 and UNE-EN 15978, measure the impacts on the environment during the extraction, production, transport, usage and end-of-life phases [30, 31]. The study shows that the use of LDPE concrete fibers in place of virgin polymer fibres in concrete production can save 25–40% of fossil fuel consumption, 30–50% of CO_2 emission and 60–80% of water consumption [32, 33].

Moreover, using a portion of natural aggregates in their place helps to minimize the use of quarries, habitat destruction, and transport-related emissions [34]. Recycling energy inputs, fiber treatment processes and end-of-life scenarios, however, affect the outcome of LCA, and therefore have to be taken into consideration on a regional basis [35].

IV. Review Methodology

This is a systematic review which abides by a structured literature search and synthesis protocol. Using the following keywords, the academic databases such as Scopus, Web of Science, ScienceDirect, and IEEE Xplore were searched: "LDPE concrete", "recycled low-density polyethylene fiber", "plastic waste reinforcement", "green concrete mechanical properties", and "sustainable construction polymers". The search limited to peer-reviewed journal articles, conference papers and technical reports, from 2015 to 2025.

The inclusion criteria were based on experimental data of incorporation of LDPE in cementitious composites, quantification of mechanical/durability parameters and sustainability assessment. Eighty-seven (87) relevant studies were initially screened and 42 studies were included in the detailed analysis that fulfilled all inclusion criteria. The data has been grouped according to the following categories: fiber dosage, geometry, treatment method, mechanical response, durability performance and LCA parameters. To ensure consistency and accuracy, cross verification was carried out by following cited references and meta-analytical trends.

V. Fresh Properties Of LDPE-Reinforced Concrete

Workability

The introduction of RLDFs always decreases the workability of the concrete because of fiber interlocking, increase of internal frictions and absorption of water by the polymer surface [36]. Typical reported slump reductions of 15-40% exist for fiber levels between 0.5 and 2.0% by volume. When dosages are optimized within the range of 0.6% to 1.2% [38] workability is within acceptable construction limits, such as EFNA RC guidelines for SCC. The use of polycarboxylate-based superplasticizers (0.5–1.5% of the cement weight) is an effective way to compensate for fluidity loss and does not affect the strength development [39].

Wet Density

It can be seen that LDPE has a lower specific gravity (0.92 g/cm^3) than that of concrete (3.15 g/cm^3) and aggregate (2.65 g/cm^3) which contributes to the proportional decrease in fresh concrete density [40]. Studies report wet density reductions from 2350 kg/m^3 to 2220–2280 kg/m^3 at 1.0% RLDF content [41]. This can restrict the use for applications with high mass density, but it is advantageous for lightweight construction, thermal insulation and reduction of seismic loads [42]. Avoiding excessive loss of density can be achieved by optimizing mix proportions and maintaining homogeneous dispersion of the fibers.

VI. Hardened Mechanical Properties

Compressive Strength

The compressive strength is not following a linear pattern with regard to RLDF incorporation. The small-scale additions (0.25-0.75%) can provide only a small-scale increase in strength (2-8%) because they provide increased matrix cohesion, decreased microcracking and improved stress distribution [43]. When the compressive strength falls below 1.0%, it is generally believed that the bonding at the interface is poor, fibers tend to cluster together, and there is a greater number of voids in the product [44].

The surface-treated LDPE fibers (such as plasma-etched or silane coated) have better compressive retention and only < 5% loss of compressive strength at 1.5% dosage [45]. It has been found that for best compressive performance, the content of RLDF should be maintained between 0.75–1.0% [46].

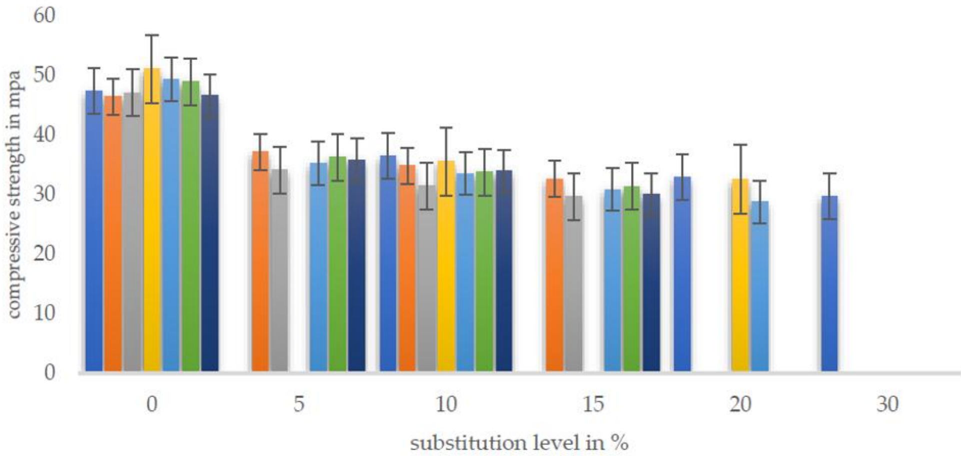

Fig 5: The compressive strength of LDPE in various studies. [77]

Flexural and Split Tensile Strength

RLDFs greatly improve flexural and split tensile strengths due to its efficient crack bridging mechanisms. The flexural strength was found to improve by 12-28% with 0.6-1.2 % fiber content and highest flexural strength was exhibited at 1.0 % fiber content [47]. The increase in split tensile strengths lie between 15–35% which are directly related to fiber aspect ratio and dispersion quality [48].

Due to the ductile properties of LDPE, significant post-crack deformations can be seen, which makes the application of RLDF-reinforced concrete appropriate for application where energy absorption and fatigue resistance is required [49]. If the dosage is too high (more than 1.5%), the strength is reduced because the fibers gather in clumps and the matrix continuity is lost [50].

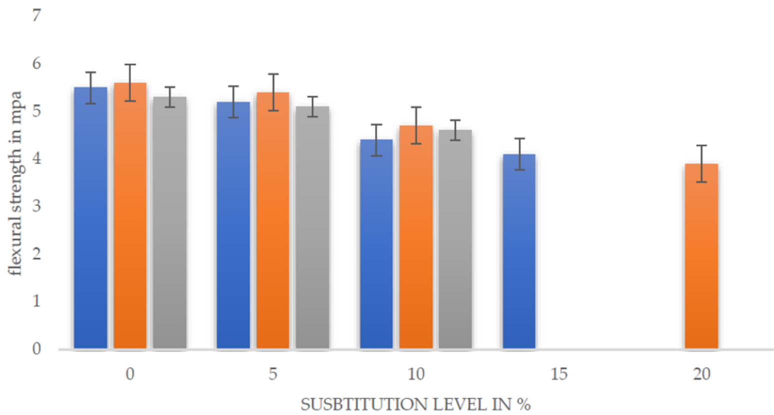

Fig 6: The flexural strength of LDPE in various studies. [77]

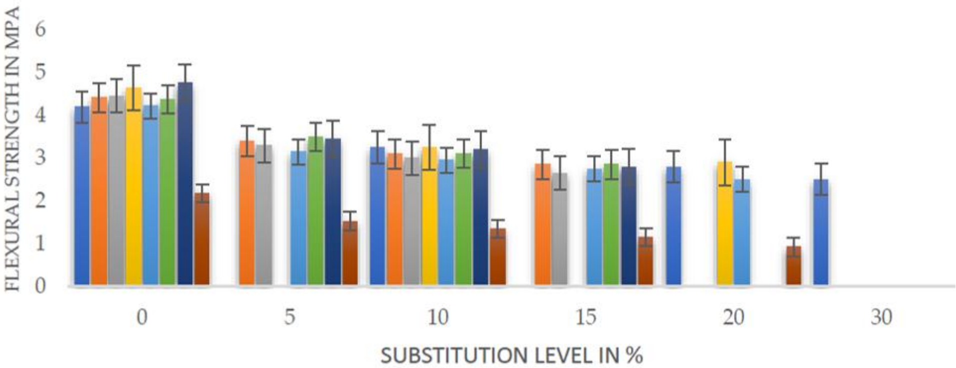

Fig 7: The splitting tensile strength of LDPE in various studies. [77]

MOE (Modulus of Elasticity) and Toughness

At low dosage of RLDF (0.25%–0.75%), the MOE slightly increases (3–10%) due to the fiber reinforcement, which contributes to stiffening [51]. MOE reaches a plateau or marginally decreases at and above 1.0%, where the material starts to behave in a ductile rather than elastic fashion [52]. The high strain capacity and crack arresting properties of LDPE significantly (2–4×) increases toughness (as measured by area under the load-deflection curve) [53]. The impact resistance tests confirm that the energy absorbed by RLDF concrete is higher than that for other mortars, and the fractured pattern presents a pull-out of the fibers and not brittle rupture [54].

VII. Durability And Environmental Resistance

Chemical and Alkaline Resistance

LDPE is highly resistant to pH 12.5 alkaline environment, with more than 90% of tensile strength after 180 days in alkaline solutions [55]. At 1.0% RLDF content, 20-35% reduction in chloride ion penetration is due to refined pore structure and crack mitigation [56]. Limited degradation occurs in sulfate or acid exposure tests; however, surface erosion can occur after extended exposures to strong acids [57]. The water absorption is poor due to the hydrophobicity of LDPE which increases its resistance to the freeze thaw cycle [58].

Shrinkage and Cracking Mitigation

RLDF incorporation has a significant effect on reducing plastic shrinkage cracking, which is one of the key concerns in early age concrete. The doses of 0.4-1.2% reduce the crack width by 50-70% in the first 24 hours after casting [59]. The modulus of elasticity of LDPE fibres should not differ too much from the modulus of elasticity of hydrating cement paste, which makes it possible to restrain tensile stress caused by the capillary water evaporation [60]. The long-term drying shrinkage is also reduced, but too much fiber will cause internal stress concentrations [61].

Ultrasonic Pulse Velocity (UPV) and Internal Integrity

UPV testing shows that RLDF introduction causes a slight decrease in pulse velocity (2–6%) that is attributed to higher internal porosity in the composite materials and more heterogeneity in the fiber-matrix interface [62].

In fact, the UPV values lie within "good" to "excellent" quality ranges (3.5 km/s and above) at doses ≤1.0%, which means that there is good homogeneity and structural integrity [63]. RLDF concrete has also been verified by non-destructive evaluation techniques to ensure good compaction, good internal structures, and free of cracks, if it is properly mixed [64].

VIII. Microstructural And Thermal Behavior

Fiber-Matrix Interface and SEM Analysis

The untreated fibres of LDPE have smooth surfaces, which shows little adhesion of cement hydration product and consequently, under tension, the failure occurs at the fracture. The surface-treated fibers (corona plasma, NaOH etching) are roughened, micro-etched and provided with improved C-S-H gel bonding, which changes the failure mode to fiber rupture [66]. Polymer hydrophobicity causes the thickness of the interfacial transition zone (ITZ) to be 10-20 μm wider in LDPE concrete, which is reduced by optimizing the W/C ratios and using supplementary cementitious materials (SCMs) [67].

Thermal Conductivity and Fire Resistance

The low thermal conductivity (0.33-0.38 W/m·K) of LDPE can improve the thermal insulation performance of the concrete. The heat transfer of the building envelope has a positive effect on the thermal insulation performance of the concrete. LDPE fibers will soften and vaporize at high temperatures (200-400°C) forming micro-channels that relieve the internal vapor pressure and decrease the formation of explosive spalling [69]. Mechanical properties get weaker when the temperature exceeds 300°C, but the integrity is still acceptable for non-structural applications such as fireproofing [70]. High-temperature strength loss can be offset by combining reinforcement of steel or basalt fibers [71].

IX. Structural Applications And Design Implications

Pavement and Slab Thickness Optimization

The addition of 0.5–1.0% RLDFs can reduce the thickness of concrete pavement slabs by 8-14% still maintaining fatigue resistance and load-bearing capacity [72].

PCA design methodologies have been verified that better flexural toughness and crack control enable to make the sections thinner without sacrificing service life [73]. They can be used for residential driveways, industrial flooring, and pedestrian walkways.

Suitable Structural and Non-Structural Uses

The RLDF concrete is suitable for semi-structural and non-structural elements:

- Precast blocks, pavers and architectural panels.
- Marine & coastal structures (corrosion-resisting).
- Lightweight partition walls and insulating boards.
- Crack repair mortars and shotcretes for cracking Sustainable urban infrastructure (Structure of benches, barriers, landscaping)

Standardization and Code Compliance

There are no specific requirements in the current building codes (e.g. ACI 318, Eurocode 2) to address plastic fiber reinforcement, requiring performance-based design approaches [74]. Fiber dosage limits, required surface treatment protocols, and standardized testing protocols were recommended in the research to enable regulatory acceptance [75]. The need for cooperation between industry, academia and standards organizations is essential for widespread adoption.

X. Conclusion And Future Research Directions

This review reveals that recycled low-density polyethylene fibers (RLDFs) have great potential as an alternative reinforcement for green concrete applications. RLDFs effectively fill in microcracks at the optimal dosage (from 0.5% to 1.2% by volume) in both the plastic and hardened phase of concrete, improving flexural and tensile strengths, with significant impact resistance and energy absorption properties. Furthermore, these fibers help to control a major durability problem that occurs in contemporary concrete mixes: plastic shrinkage cracking. Life Cycle Assessment (LCA) results show that RLDFs significantly decrease the environmental impact of concrete production when compared with the use of synthetic or steel fibers.

In particular, the recycling route will reduce the amount of post-consumer plastic waste sent to landfill, and reduce the use of fossil fuel resources, greenhouse gas emissions and freshwater resources that are normally consumed in the extraction and manufacturing of virgin reinforcement materials.

This mechanical improvement and ecological protection are very much in line with the global aim of a circular economy and the construction industries strive to create low carbon, resource efficient building systems. Despite these good properties, a number of technical and regulatory challenges need to be overcome one by one before RLDF-reinforced concrete can become a commercially viable product. Polyethylene fibers naturally lower the workability of fresh concrete, and may require careful adjustments to the water to cement ratio, or optimization of water reducing admixtures to achieve a reasonable flow and compaction. Also, there is a documented trade-off between the inclusion of fiber and the slight decrease in compressive strength, and a weak ITZ bonding between the cement paste and RLDFs may cause reduced efficiency in stress transfer and durability in the long-term, in cyclic or sustained loading.

Add to this the lack of a consistent, common (material-specific) set of design codes, test protocols, and quality assurance processes for recycled polymer fibers, and engineers, specifiers, and regulatory entities are hesitant. The material design challenges that must be addressed include development of performance-based design guidelines that explicitly consider the viscoelastic and anisotropic behavior of RLDFs, targeted research into surface modification techniques, and optimized fiber aspect ratio. By employing the interdisciplinary approach and pilot-scale validation, many of these challenges can be addressed and overcome in a way that paves the way toward more sustainable and high-performance concrete infrastructure.

Future research should prioritize:

- Surface Modification Technologies: Development of cost-effective and scalable surface modification processes (plasma, bio-coatings, nano-silica grafting) to improve fibre-matrix adhesion.
- Hybrid Reinforcement Systems: Using a mix of RLDFs and steel or natural fibres to achieve a combination of strength, ductility and durability.
- Long Term Field Performance: Multi-year monitoring of RLDF concrete in real field environments and loading.
- Standardization and Code Integration: Formulating guidelines for dosage, testing and design criteria based on performance for regulatory acceptance.
- Advanced LCA and Techno-Economic Modeling: Sustainability assessments and cost benefit analyses at the region level for industrial scale implementation.

The use of LDPE in green concrete is aligned with the principles of the circular economy, providing a potential solution to help remove long-lived plastic waste from the environment and promote the development of green infrastructure. LDPE-reinforced concrete could be developed from experiment to mainstream construction solution by the proper and optimized research and industry-academy collaboration.

References

[1]. A. R. De Azevedo Et Al., "Technological Performance Of Açaí Natural Fibre Reinforced Cement-Based Mortars," J. Build. Eng., Vol. 33, P. 101675, 2021.
[2]. D. Lu Et Al., "A Dynamic Elastoplastic Model Of Concrete Based On A Modeling Method With Environmental Factors As Constitutive Variables," J. Eng. Mech., Vol. 149, No. 12, P. 04023102, 2023.
[3]. European Plastics, "Plastics—The Facts 2023: An Analysis Of European Plastics Production, Demand And Waste Data," Brussels, Belgium, 2023.
[4]. R. Geyer, J. R. Jambeck, And K. L. Law, "Production, Use, And Fate Of All Plastics Ever Made," Sci. Adv., Vol. 3, No. 7, P. E1700782, 2017.
[5]. Unep, "Single-Use Plastics: A Roadmap For Sustainability," United Nations Environment Programme, Nairobi, Kenya, 2018.
[6]. N. H. Zulkernain Et Al., "Utilisation Of Plastic Waste As Aggregate In Construction Materials: A Review," Constr. Build. Mater., Vol. 296, P. 123669, 2021.
[7]. Iea, "Tracking Clean Energy Progress 2023: Cement Sector," International Energy Agency, Paris, France, 2023.
[8]. B. A. Tayeh Et Al., "Performance Of Sustainable Concrete Containing Different Types Of Recycled Plastic," J. Clean. Prod., Vol. 328, P. 129517, 2021.
[9]. A. I. Almohana Et Al., "Producing Sustainable Concrete With Plastic Waste: A Review," Environ. Chall., Vol. 9, P. 100626, 2022.
[10]. T. Ochi, S. Okubo, And K. Fukui, "Development Of Recycled Pet Fiber And Its Application As Concrete-Reinforcing Fiber," Cem. Concr. Compos., Vol. 29, No. 6, Pp. 448–455, 2007.
[11]. N. Pešić Et Al., "Mechanical Properties Of Concrete Reinforced With Recycled Hdpe Plastic Fibres," Constr. Build. Mater., Vol. 115, Pp. 362–370, 2016.
[12]. X. Li Et Al., "Functions And Impacts Of Plastic/Rubber Wastes As Eco-Friendly Aggregate In Concrete–A Review," Constr. Build. Mater., Vol. 240, P. 117913, 2020.
[13]. K. Aziz, "Mechanical Properties For Ordinary Concrete Containing Waste Plastic Fibers," Iraqi J. Civ. Eng., Vol. 11, No. 2, Pp. 33–44, 2019.
[14]. F. U. A. Shaikh, "Tensile And Flexural Behaviour Of Recycled Polyethylene Terephthalate (Pet) Fibre Reinforced Geopolymer Composites," Constr. Build. Mater., Vol. 245, P. 118438, 2020.
[15]. J. K. Park And M. O. Kim, "Mechanical Properties Of Cement-Based Materials With Recycled Plastic: A Review," Sustainability, Vol. 12, No. 21, P. 9060, 2020.
[16]. G. W. Ehrenstein, G. Riedel, And P. Trawiel, Thermal Analysis Of Plastics: Theory And Practice. Munich, Germany: Carl Hanser Verlag, 2004.
[17]. H. Zhang Et Al., "Microscale Testing And Modelling Of Cement Paste As Basis For Multi-Scale Modelling," Materials, Vol. 9, No. 11, P. 917, 2016.
[18]. S. Yin Et Al., "Use Of Macro Plastic Fibres In Concrete: A Review," Constr. Build. Mater., Vol. 93, Pp. 180–188, 2015.
[19]. D. Silva Et Al., "Degradation Of Recycled Pet Fibers In Portland Cement-Based Materials," Cem. Concr. Res., Vol. 35, No. 9, Pp. 1741–1746, 2005.
[20]. A. Rahimi And J. M. García, "Chemical Recycling Of Waste Plastics For New Materials Production," Nat. Rev. Chem., Vol. 1, No. 6, Pp. 1–11, 2017.
[21]. J. Hopewell, R. Dvorak, And E. Kosior, "Plastics Recycling: Challenges And Opportunities," Philos. Trans. R. Soc. B Biol. Sci., Vol. 364, No. 1526, Pp. 2115–2126, 2009.
[22]. F. Zhang Et Al., "Polyethylene Upcycling To Long-Chain Alkylaromatics By Tandem Hydrogenolysis/Aromatization," Science, Vol. 370, No. 6515, Pp. 437–441, 2020.
[23]. R. Tuladhar And S. Yin, "Sustainability Of Using Recycled Plastic Fiber In Concrete," In Use Of Recycled Plastics In Eco-Efficient Concrete, 2019, Pp. 441–460.
[24]. V. Francioso Et Al., "Effect Of Elevated Temperature On Flexural Behavior And Fibers-Matrix Bonding Of Recycled Pp Fiber-Reinforced Cementitious Composite," Constr. Build. Mater., Vol. 269, P. 121243, 2021.
[25]. A. C. Bhogayata And N. K. Arora, "Workability, Strength, And Durability Of Concrete Containing Recycled Plastic Fibers And Styrene-Butadiene Rubber Latex," Constr. Build. Mater., Vol. 180, Pp. 382–395, 2018.
[26]. B. A. Tayeh Et Al., "Influence Of Microsilica And Polypropylene Fibers On The Fresh And Mechanical Properties Of Ultra-High Performance Geopolymer Concrete," Case Stud. Constr. Mater., Vol. 17, P. E01367, 2022.
[27]. D. E. Macarthur, D. Waughray, And M. Stuchtey, "The New Plastics Economy: Rethinking The Future Of Plastics," World Economic Forum, Geneva, Switzerland, 2016.
[28]. J. Raynaud, "Valuing Plastics: The Business Case For Measuring, Managing And Disclosing Plastic Use In The Consumer Goods Industry," Unep, 2014.
[29]. P. Ghisellini And S. Ulgiati, "Circular Economy Transition In Italy: Achievements, Perspectives And Constraints," J. Clean. Prod., Vol. 243, P. 118360, 2020.
[30]. Y. Decorte Et Al., "Guidelines For Defining The Reference Study Period And System Boundaries In Comparative Lca Of Building Renovation And Reconstruction," Int. J. Life Cycle Assess., Vol. 28, No. 2, Pp. 111–130, 2023.
[31]. A. M. Braga, J. D. Silvestre, And J. De Brito, "Compared Environmental And Economic Impact From Cradle To Gate Of Concrete With Natural And Recycled Coarse Aggregates," J. Clean. Prod., Vol. 162, Pp. 529–543, 2017.
[32]. Z. Guo Et Al., "Mechanical Properties, Durability And Life-Cycle Assessment Of Waste Plastic Fiber Reinforced Sustainable Recycled Aggregate Self-Compacting Concrete," J. Build. Eng., Vol. 91, P. 109683, 2024.
[33]. J. Manso-Morato Et Al., "Fiber-Reinforced Concrete And Its Life Cycle Assessment: A Systematic Review," J. Build. Eng., Vol. 94, P. 110062, 2024.
[34]. L. Gu And T. Ozbakkaloglu, "Use Of Recycled Plastics In Concrete: A Critical Review," Waste Manag., Vol. 51, Pp. 19–42, 2016.
[35]. S. T. A. Gillani Et Al., "Synergistic Optimization: A Comprehensive Life Cycle Assessment For High-Performance Concrete With Recycled Aggregates And Next-Gen Nylon Waste Fibers," Constr. Build. Mater., Vol. 430, P. 136491, 2024.
[36]. M. Lakhiar Et Al., "Flexural Performance Of Concrete Reinforced By Plastic Fibers," Eng. Technol. Appl. Sci. Res., Vol. 8, 2018.
[37]. A. I. Al-Hadithi And N. N. Hilal, "The Possibility Of Enhancing Some Properties Of Self-Compacting Concrete By Adding Waste Plastic Fibers," J. Build. Eng., Vol. 8, Pp. 20–28, 2016.
[38]. M. Efnarc, "The European Guidelines For Self-Compacting Concrete," Specif. Prod. Use, 2005.
[39]. B. Ramesh Et Al., "Detailed Study On Flexural Strength Of Polypropylene Fiber Reinforced Self-Compacting Concrete," Mater. Today Proc., Vol. 22, Pp. 1054–1058, 2020.
[40]. J. Thorneycroft Et Al., "Performance Of Structural Concrete With Recycled Plastic Waste As A Partial Replacement For Sand," Constr. Build. Mater., Vol. 161, Pp. 63–69, 2018.

[41]. I. Mercante Et Al., "Mortar And Concrete Composites With Recycled Plastic: A Review," Sci. Technol. Mater., Vol. 30, Pp. 69–79, 2018.
[42]. A. A. Mohammed And A. A. F. Rahim, "Experimental Behavior And Analysis Of High Strength Concrete Beams Reinforced With Pet Waste Fiber," Constr. Build. Mater., Vol. 244, P. 118350, 2020.
[43]. K. Zhao Et Al., "Mechanical Tests And Engineering Applicability Of Fibre Plastic Concrete Used In Tunnel Design In Active Fault Zones," Tunn. Undergr. Space Technol., Vol. 88, Pp. 200–208, 2019.
[44]. F. Mehvish Et Al., "Characterization Of Concrete Incorporating Waste Polythene Bags Fibers," Pak. J. Eng. Appl. Sci., Vol. 26, No. 1, 2020.
[45]. H. Mohammadhosseini Et Al., "Waste Metalized Film Food Packaging As Low Cost And Ecofriendly Fibrous Materials In The Production Of Sustainable And Green Concrete Composites," J. Clean. Prod., Vol. 258, P. 120726, 2020.
[46]. P. S. N. D. Balte Sanjaykumar, "Use Of Plastic Fiber In The Concrete," Ssrg Int. J. Civ. Eng., Vol. 4, No. 11, P. 3, 2017.
[47]. L. A. Pereira De Oliveira And J. P. Castro-Gomes, "Physical And Mechanical Behaviour Of Recycled Pet Fibre Reinforced Mortar," Constr. Build. Mater., Vol. 25, No. 4, Pp. 1712–1717, 2011.
[48]. A. Mohammadinia Et Al., "Strength Evaluation Of Utilizing Recycled Plastic Waste And Recycled Crushed Glass In Concrete Footpaths," Constr. Build. Mater., Vol. 197, Pp. 489–496, 2019.
[49]. D. Foti, "Preliminary Analysis Of Concrete Reinforced With Waste Bottles Pet Fibers," Constr. Build. Mater., Vol. 25, No. 4, Pp. 1906–1915, 2011.
[50]. C. Marthong And S. Marthong, "An Experimental Study On The Effect Of Pet Fibers On The Behavior Of Exterior Rc Beam-Column Connection Subjected To Reversed Cyclic Loading," Structures, Vol. 5, Pp. 175–185, 2016.
[51]. D. Atlaoui And Y. Bouafia, "Experimental Characterization Of Concrete Beams Elements Reinforced By Long Fiber Chips," J. Adhes. Sci. Technol., Vol. 31, No. 8, Pp. 844–857, 2017.
[52]. S. S. Karanth Et Al., "Shear And Impact Strength Of Waste Plastic Fibre Reinforced Concrete," Adv. Concr. Constr., Vol. 5, No. 2, P. 173, 2017.
[53]. A. Al-Hadithi Et Al., "Flexural Behaviour Of Reinforced Concrete Beams Containing Waste Plastic Fibers," Iop Conf. Ser.: Mater. Sci. Eng., 2020, P. 012173.
[54]. K. Hannawi Et Al., "Physical And Mechanical Properties Of Mortars Containing Pet And Pc Waste Aggregates," Waste Manag., Vol. 30, No. 11, Pp. 2312–2320, 2010.
[55]. J.-P. Won Et Al., "Long-Term Performance Of Recycled Pet Fibre-Reinforced Cement Composites," Constr. Build. Mater., Vol. 24, No. 5, Pp. 660–665, 2010.
[56]. V. G. Ghorpade And H. S. Rao, "The Behaviour Of Self Compacting Concrete With Waste Plastic Fibers When Subjected To Chloride Attack," Mater. Today Proc., Vol. 5, No. 1, Pp. 1501–1508, 2018.
[57]. A. C. Bhogayata And N. K. Arora, "Impact Strength, Permeability And Chemical Resistance Of Concrete Reinforced With Metalized Plastic Waste Fibers," Constr. Build. Mater., Vol. 161, Pp. 254–266, 2018.
[58]. J. C. A. Galvão Et Al., "Use Of Waste Polymers In Concrete For Repair Of Dam Hydraulic Surfaces," Constr. Build. Mater., Vol. 25, No. 2, Pp. 1049–1055, 2011.
[59]. N. Pešić Et Al., "Mechanical Properties Of Concrete Reinforced With Recycled Hdpe Plastic Fibres," Constr. Build. Mater., Vol. 115, Pp. 362–370, 2016.
[60]. T. Rahmani Et Al., "Application Of Different Fibers To Reduce Plastic Shrinkage Cracking Of Concrete," In 7th Rilem Int. Conf. Cracking Pavements, 2012, Pp. 635–642.
[61]. A. Sivakumar And M. Santhanam, "A Quantitative Study On The Plastic Shrinkage Cracking In High Strength Hybrid Fibre Reinforced Concrete," Cem. Concr. Compos., Vol. 29, No. 7, Pp. 575–581, 2007.
[62]. M. Mastali Et Al., "The Impact Resistance And Mechanical Properties Of The Reinforced Self-Compacting Concrete Incorporating Recycled Cfrp Fiber With Different Lengths And Dosages," Compos. Part B: Eng., Vol. 112, Pp. 74–92, 2017.
[63]. A. Grilli Et Al., "Experimental Investigation On Fibre-Reinforced Cement-Treated Materials Using Reclaimed Asphalt," Constr. Build. Mater., Vol. 38, Pp. 491–496, 2013.
[64]. X. Diao Et Al., "Enhanced Dynamic Compressive Performance Of Silicon Carbide Whiskers-Modified Mortars," Constr. Build. Mater., Vol. 432, P. 136626, 2024.
[65]. F. U. A. Shaikh, "Tensile And Flexural Behaviour Of Recycled Polyethylene Terephthalate (Pet) Fibre Reinforced Geopolymer Composites," Constr. Build. Mater., Vol. 245, P. 118438, 2020.
[66]. S. B. Kim Et Al., "Material And Structural Performance Evaluation Of Recycled Pet Fiber Reinforced Concrete," Cem. Concr. Compos., Vol. 32, No. 3, Pp. 232–240, 2010.
[67]. J. C. A. Galvão Et Al., "Use Of Waste Polymers In Concrete For Repair Of Dam Hydraulic Surfaces," Constr. Build. Mater., Vol. 25, No. 2, Pp. 1049–1055, 2011.
[68]. K.-H. Kim Et Al., "An Experimental Study On Thermal Conductivity Of Concrete," Cem. Concr. Res., Vol. 33, No. 3, Pp. 363–371, 2003.
[69]. J. R. Camilo Et Al., "Concrete With Rejected Recyclable Plastic Waste At High Temperatures," Mag. Concr. Res., 2020.
[70]. V. Francioso Et Al., "Effect Of Elevated Temperature On Flexural Behavior And Fibers-Matrix Bonding Of Recycled Pp Fiber-Reinforced Cementitious Composite," Constr. Build. Mater., Vol. 269, P. 121243, 2021.
[71]. A. Hassan Et Al., "Effect Of Hybrid Polypropylene Fibers On Mechanical And Shrinkage Behavior Of Alkali-Activated Slag Concrete," Constr. Build. Mater., Vol. 411, P. 134485, 2024.
[72]. F. Ahmadi Et Al., "Mechanical Properties Of The Concrete Containing Recycled Fibers And Aggregates," Constr. Build. Mater., Vol. 144, Pp. 392–398, 2017.
[73]. R. G. Packard, "Thickness Design For Concrete Highway And Street Pavements," 1984.
[74]. Aci Committee 318, "Building Code Requirements For Structural Concrete (Aci 318-19) And Commentary," American Concrete Institute, Farmington Hills, Mi, 2019.
[75]. B. A. Tayeh Et Al., "The Utilization Of Recycled Aggregate In High Performance Concrete: A Review," J. Mater. Res. Technol., Vol. 9, No. 4, Pp. 8469–8481, 2020.
[76]. D.E. Macarthur, D. Waughray, M. Stuchtey, The New Plastics Economy, Rethinking The Future Of Plastics, World Econ. Forum (2016).
[77]. N. S. Mashaan And C. A. E. Ouano, "An Investigation Of The Mechanical Properties Of Concrete With Different Types Of Waste Plastics For Rigid Pavements," Applied Mechanics, Vol. 6, No. 1, P. 9, 2025, Doi: 10.3390/Applmech6010009.
[78]. A. Yadav, A. Chandra, And S. Singh, "Study On Application Of Waste Plastic In The Construction Industry," Materials Today: Proceedings, Vol. 64, Pp. 1455–1458, 2022, Doi: 10.1016/J.Matpr.2022.04.743.